

with the break-up of ice. In both years storms have occurred during the first 10 days of December. High plankton count is fairly well timed with high turbidity. This is expected since part of the turbidity consists of plankton. Thus both are associated with water turnover. High plankton counts extend into June each year probably because of increased light and favorable growing conditions, and show a low count in July and August because of the generally quiet condition of Lake St. Clair. Alum dosage shows the spring and late fall peaks to coincide with high plankton and turbidity rates at the same time. Alum application is generally low in the winter when the ice cover is on Lake St. Clair. At other

times alum is closely correlated with turbidity and plankton. In most cases the increased *B. coli* is coordinated with increased wind velocity, increased plankton, or thaws in winter and ice flow in spring. The average daily gallons of water run per filter (between washes) shows that when turbidity and plankton are low as in winter, the filter run is high, and vice versa. Winds, ice, temperature, and precipitation are causes; turbidity, plankton, bacteria, alum, *B. coli* amount, and length of filter run are usually results. Thus the filtration operators have a complex set of factors with which to deal—the weather factors are always present in some form or other.

THE SANTO DOMINGO HURRICANE OF SEPTEMBER 1 to 5, 1930

By F. EUGENE HARTWELL

[Weather Bureau Office, San Juan, P. R., September, 1930]

There was no ship in the Atlantic near enough to report the formation of this storm to the east of the Lesser Antilles, so the first intimation obtainable was in the regular morning reports of the Weather Bureau observers from Barbados to Dominica, each showing a barometer reading only slightly below normal, but a wind circulation decidedly abnormal. The directions ranged from north at Dominica, through northwest and west, to south at Barbados. The observer at Dominica also sent, in addition to his usual code report, "evidences of approaching hurricane." Cautionary advice was immediately sent out to the area from Barbados to St. Thomas, and special observations requested.

At noon communication with Dominica had already ceased, but fortunately the steamship *Lady Hawkins* was a short distance to the westward, and her report, together with those of the nearer islands, and that of the steamship *Invella*, which was just west of Guadeloupe, definitely located the center. It was over or very near Dominica at noon of the first. With this definite information to work from, the storm track was plotted as passing south of Porto Rico and probably Santo Domingo and Haiti, and advisory warnings issued Monday afternoon accordingly.

While the storm was estimated to be of relatively small diameter, no direct evidence was obtainable of this detail until it had passed over Santo Domingo City on the third. Authentic reports place the destructive diameter at less than 20 miles. Reference to barograph traces will show how rapid was the fall and recovery of air pressure during the storm. Three of these traces were reconstructed from readings taken at short intervals by officers of the steamship *Coamo*, which lay just off the shore at the Dominican capital throughout the storm, of the steamship *Catherine*, which encountered the full fury of the elements just south of Saona Island on the return trip from Santo Domingo to San Juan, and by the observer at Dominica. The fourth is a copy of an actual barograph trace, made by the instrument in charge of Mr. A. Ortori, observer at Santo Domingo. This record was made on a sheet limited to 28 inches, the copy being transferred to a sheet with a 27-inch limit and the record extended to the low limit noted by Mr. Ortori on one of his mercurial barometers, namely, 700 millimeters, or 27.56 inches. On the recovery, with the wind shift from north-northeast to south-southwest, the rain stopped the automatic record. The roof carrying the anemometer installation was damaged when the record had reached 100 miles per hour, some time before the vortex passed. The Pan-American Airways anemometer near by is reported to have recorded up to 180 miles per hour before it was

carried away. This instrument is a 4-cup Robinson, so its record must be discounted. Wind velocities, estimated by those acquainted by long experience in these areas, vary from 80 to 100 at Dominica to 150 to 200 miles per hour at Santo Domingo. Where the steamship *Coamo* was lying, offshore, the sea was not so heavy, and the direct damage, aside from water damage to interior fittings, was caused by wind pressure. This was sufficient to break pilot house and cabin windows, and list the ship over to 45° from the perpendicular. Doubtless it was only the active pumping of ballast tanks to the high side which kept her afloat. The steamship *Catherine* suffered relatively more because of being more exposed to heavier seas.

The steamship *Antilles* of the French Transatlantic Line entirely avoided the storm in her 48 hours of maneuvering between Jacmel, Haiti, and Santo Domingo City. Her lowest barometer during the 2d and 3d was 29.67 inches, and she entirely avoided destructive winds.

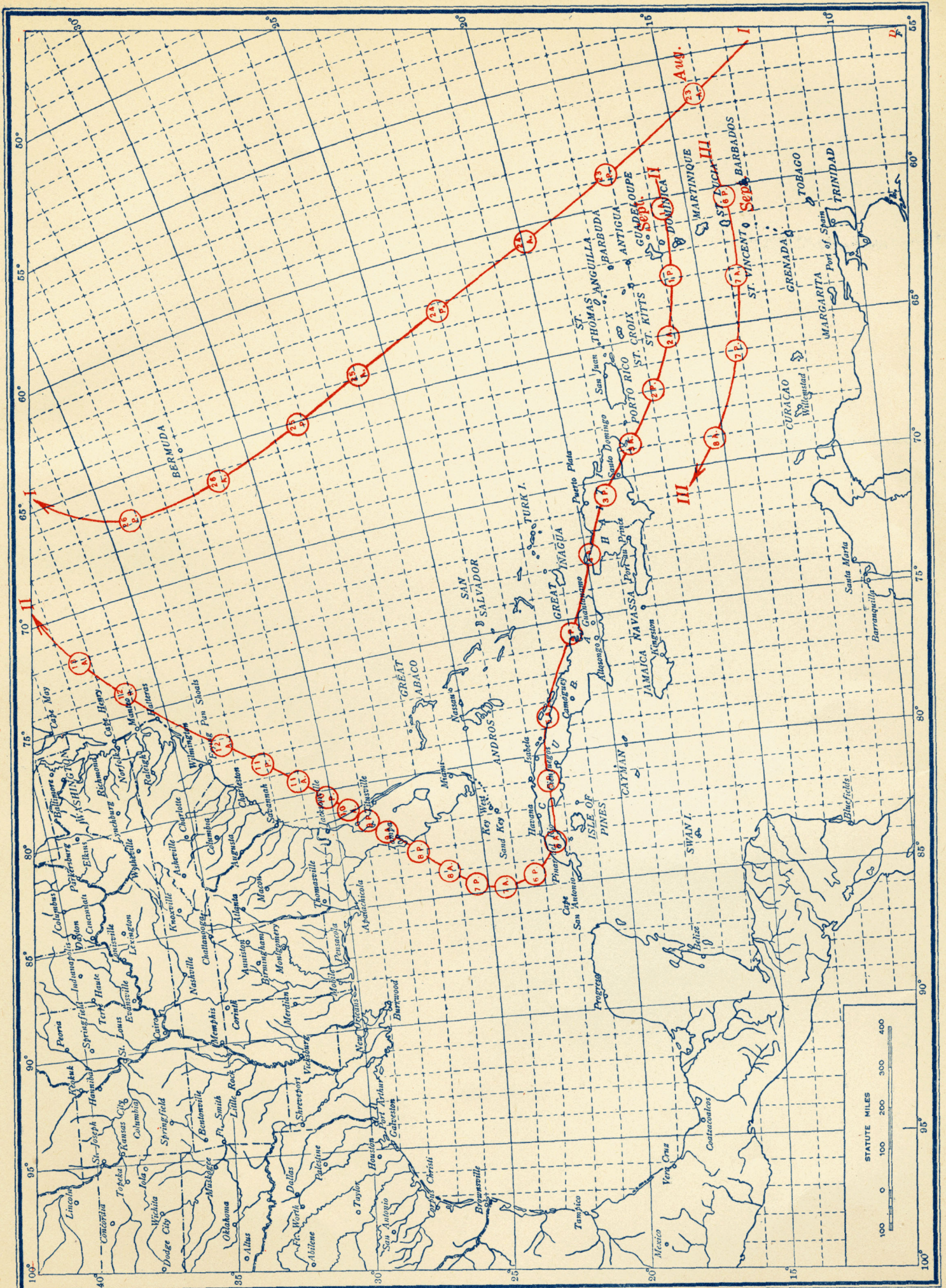
From available observations the trajectory of this storm was almost a straight line from Dominica to the Florida Straits region. Its small diameter makes the assumption probable that the center passed much nearer the south coast of Porto Rico than would be indicated by parallel effects of a wider storm or than was first estimated in plotting the probable path of this storm. Lowest pressures at San Germain and Guayama were only 29.69 and 29.59 inches, respectively. Lowest at Ponce was 29.74 inches, the difference between that and the San Germain report probably being due to difference in elevation. It was learned several days later that winds of sufficient force to damage plantains and other minor crops prevailed in the extreme southwest of Porto Rico, in the Cabo Rojo district, and mountainous seas ravaged the coast from Humacao to Mayaguez.

The forward movement in its path varied greatly, there being a decided slowing up after it passed Porto Rico. During this part of its path it traveled at less than 8 miles per hour. After passing into the Atlantic to the northwestward it resumed a more normal forward movement, but still in the same general direction.

The chart showing this trajectory, Track No. II, also shows the other two which have been reported so far this season. No. I of late in August, which passed west of Bermuda and thence northeastward to the North Atlantic, and No. III, which was reported but twice, first by a Pan American Airways plane on September 6 near St. Lucia, and again at midnight of the 7th by the steamship *Rhodopis*. This disturbance dissipated before it reached proximity to any land station.

Path of Santo Domingo Hurricane, September, 1930 (No. II). See text.
(Plotted by F. E. Hartwell and A. J. Haidle)

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On the island of Haiti-Santo Domingo the damage was apparently negligible outside of the Dominican capital and its immediate environs. The surface friction over the mountain masses west of the city damped the storm to such an extent that beyond that point it was barely traceable, and it finally passed to the northeast over the Atlantic.

While the destructive effects of this storm in Santo Domingo, where 4,000 lives were lost¹ and property damage has been roughly estimated at \$50,000,000, would class it as a major disaster, for Porto Rico it will be listed among the "beneficial" storms in that it caused much needed moderate to heavy rains throughout the island. The greatest amount reported was over 6 inches at Cabo Rojo; the least, strangely enough, was over the middle of the south coast, where it was under an inch. On the north coast it varied from somewhat less than an inch to more than 2 inches; in the interior from 1 to 4 inches.

APPENDIX I.—STORM CONDITIONS ENCOUNTERED BY THE STEAMSHIP "COAMO" SEPTEMBER 3, 1930

By BENJAMIN PARRY

[Western Bureau, New York City]

The steamship *Coamo*, flagship of the Porto Rico Line, is a vessel of 7,000 tons displacement. She plies between New York, San Juan, and Santo Domingo during the day of arrival, depending upon cargo requirements.

On September 1, the *Coamo* arrived at San Juan, but canceled her departure for Santo Domingo, due to advices that indicated a hurricane central off Dominica. The ship's barometer, 30 inches at 4 p. m., showed a downward trend during the night, and at 8 a. m., September 2, registered 29.87. Meanwhile the wind, which had been light east-southeast, backed to northeast, with moderate velocity. At 8 a. m., September 2, the following warning was issued by the San Juan office of the Weather Bureau:

Center of storm is now apparently directly south of Porto Rico, about latitude 16° 13', longitude 67° 00', moving west-northwest. Storm will not touch Porto Rico. Advise caution next 12 hours for all shipping south of Santo Domingo and Haiti.

As the *Coamo* was now hours behind schedule it was decided to sail at 3 p. m. The ship departed with a light east-southeast wind which later backed to northeast, increasing, and a slowly falling barometer. At 11 p. m. the vessel was 5 miles south of Saona Island, steering west. She now encountered a moderate northeast gale and rough sea. As the vessel progressed and passed under the lee of the land the gale moderated and light rain began falling. By midnight the barometer had dropped to 29.68, with moderate northeast gale, and light rain continuing. At 4 a. m., September 3, the barometer ceased falling and the sky appeared to be clearing. During the next five hours the barometer gradually rose and at 9 a. m. stood at 29.72. The wind remained moderate north-northeast and sky continued to brighten. At 9:30 a. m. the *Coamo* was 5 miles southeast of the city of Santo Domingo. The harbor was too rough to venture for anchorage. The ship now cruised outside, headed east with engines slow ahead, awaiting further moderation of sea within the harbor. At 10 a. m. the pressure again started downward and a tremendously high following swell and rough northeast beam sea set in. The ship pitched and rolled heavily, shipping spray over hatches and decks. By 10:30 a whole gale from northeast was encountered with driving rain, making it necessary to sound fog signals continu-

ously. During the next hour the pressure continued to fall and at 11:30 a. m. reached 29.45. The wind had attained a velocity of 125 miles per hour, and the ship became unmanageable. At noon the barometer registered 28.22, having fallen 1.23 inches in 30 minutes. The wind was now blowing 150 miles per hour which carried the rain and spray in sheets cutting the visibility to a few yards. Shortly after noon the wind velocity dropped rapidly and at 12:25 p. m. the ship was in a calm, with heavy confused sea pitching and seething, resembling a boiling cauldron. Hundreds of birds were seen flying about or resting on the ship. The barometer continued to drop, the indicator finally passed below the graduated scale and striking the attached thermometer was prevented from descending lower. The distance between the scale and thermometer corresponds to 0.10 inch, thereby indicating the lowest pressure as 27.70 (Captain Evans estimated the low point as 27.65). During this time the aneroid pumped violently, frequently rising 0.20 inch then returning to rest on the thermometer. At 1:04 p. m. the wind shifted to southwest with velocities quickly increasing until the gale raged as heavily as experienced before the center of the storm passed. At 1:25 p. m. a velocity of 150 miles was experienced, after which it gradually subsided, becoming moderate southerly at 8 p. m.

At the height of the storm rain and spray were driven in sheets hiding from view the foremast and rails. Glass was blown in, hatch covers, boat covers, and tarpaulins tossed into the sea, the radio antenna was carried away, skylights broken, and the interior of the ship drenched. The *Coamo* had but 92 tons of cargo aboard. The ship listed 20° and occasionally rolled to 40°.

Pressure readings recorded on the steamship "Coamo," September 1-3, 1930

Date	Time	Pressure	Date	Time	Pressure
		Inches			Inches
Sept. 1	3 p. m.	29.97	Sept. 3	4 a. m.	29.60
	4 p. m.	29.95		5 a. m.	29.60
	5 p. m.	29.94		6 a. m.	29.60
	5:30 p. m.	29.93		7 a. m.	29.64
	6 p. m.	29.94		8 a. m.	29.69
	7 p. m.	29.95		9 a. m.	29.72
	7:30 p. m.	29.94		10 a. m.	29.71
	8 p. m.	29.94		10:30 a. m.	29.66
	Midnight	29.92		10:35 a. m.	29.62
				11 a. m.	29.53
Sept. 2	6 a. m.	29.84		11:20 a. m.	29.45
	7 a. m.	29.86		Noon	28.22
	8 a. m.	29.87		12:43 p. m.	28.18
	9 a. m.	29.88		12:45 p. m.	28.05
	10 a. m.	29.90		12:48 p. m.	27.85
	11 a. m.	29.88		1 p. m.	27.78
	Noon	29.87		1:01 p. m.	27.70
	1 p. m.	29.85		2 p. m.	28.30
	2 p. m.	29.82		2:30 p. m.	29.40
	3 p. m.	29.80		2:40 p. m.	29.50
	4 p. m.	29.81		3 p. m.	29.54
	5 p. m.	29.80		4 p. m.	29.60
	6 p. m.	29.79		5 p. m.	29.74
	7 p. m.	29.80		6 p. m.	29.79
	8 p. m.	29.79		7 p. m.	29.80
Sept. 3	9 p. m.	29.76		8 p. m.	29.86
	10 p. m.	29.75		9 p. m.	29.90
	11 p. m.	29.71		10 p. m.	29.91
	Midnight	29.68		11 p. m.	29.92
	1 a. m.	29.67		12 p. m.	29.94
	2 a. m.	29.63			
	3 a. m.	29.62			

Pressure range from time of vessel's departure from San Juan to center of storm, 2.10 inches.

Pressure fell 0.08 in 1 minute, 1 p. m. to 1.01 p. m.; 0.20 in 3 minutes, 12.45 p. m. to 12.48 p. m.; 1.23 in 40 minutes, 11.20 to noon.

Pressure increased 0.60 in 59 minutes, 1.01 p. m. to 2 p. m.

Captain Evans made a record of pressure readings which were read by Chief Officer Otto Berggren, as frequently as ship duties permitted. The ship's barometer was compared with standard at New York, July 16, and at San Juan, September 1, and found to be correct. On September 9, the instrument was 0.02 too high, comparison being made with portable aneroid.

¹ A more recent estimate made by an official of the American Red Cross places the loss of life at 2,000, the injured at 8,000, and the property loss at \$15,000,000.—Ed.